BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

SUBJECT: Elimination of Capability to Perform Decoupled ATM Mission
Case 620

DATE: October 29, 1968

FROM: W. W. Hough

ABSTRACT

If all capability to perform a backup or alternate ATM mission decoupled from the AAP-2 Cluster is eliminated, some very minor simplifications to both the CM and the LM-A are possible. Several major configuration options are also opened, such as:

1. Moving the LM-A/MDA docking probe to the LM-A
2. Eliminating the Crew Provisions Stowage Module from the LM-A
3. Eliminating the capability to perform EVA from the LM-A
4. Moving the CMG's from the ATM to the Airlock.

Only the first of these appears attractive for the coupled mission, but it is not feasible if LM-A manual backup docking capability is retained. Manual backup docking capability would be the only way to salvage the LM-ATM in the event of a remote docking failure if decoupled mission capability is eliminated.

Because the simplifications are minor and because of the state of design of the various AAP modules, it is recommended that decoupled mission capability be retained.

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MEMORANDUM FOR FILE

Capability to perform a decoupled CM-SM/LM-ATM mission is presently required in the Apollo Applications Program. A decoupled mission plan would be adopted if the AAP-2 payload is not usable for the primary coupled ATM mission, or if the LM-A cannot dock to the MDA. The pre-planned decoupled mission is called a backup mission if the decision to adopt it is made prior to the AAP-3 CM-SM launch, or an alternate mission if the decision is made after the CM-SM launch. A list of possible failures that would force adoption of the backup or alternate mission is given in the Appendix.

There would be minor savings in both the AAP-3 CM-SM and the AAP-4 LM-A if the capability to perform a decoupled mission is eliminated. Several relatively major configuration decisions have been influenced by the requirement for decoupled mission capability, and these decisions should be reconsidered if the requirement is eliminated.

MINOR SIMPLIFICATIONS

For the decoupled mission, a flexible duct and fan are required in the CM for LM-CM cabin atmosphere exchange. In the prime mission, flexible ducts in the MDA perform this function for both the LM and CM. This CM equipment could be deleted if there is no requirement for decoupled mission capability.

CM and SM heaters will be sized for the decoupled mission as this mission imposes the severest thermal environment. Physical size of the heaters could be diminished if there is no decoupled capability.

Several LM-A data handling functions are performed by AM-MDA systems in the primary coupled mission, and will have to be performed by the CM systems in a decoupled mission. Biomedical data from a crewman in the LM-A will be transmitted by the CM. The CM must also accommodate engineering data from an EVA astronauts LM-A support systems. The voice-recording requirement will be placed on the CM recorder, and this unit might have to be requalified if the total lifetime requirement is greater than its demonstrated capability. If there is no decoupled mission capability, these CM requirements would not exist, and CM (not LM-A) interface wiring to support them could be deleted.

The requirements for ground and spaceborn computer software are not significantly different for the coupled or decoupled mission. Although some additional equations will have to be programmed for CMG momentum dump if both configurations are included, the savings in deleting decoupled mission capability are minor.

The principal simplification to the LM-A would result from elimination of design loads due to an SM-SPS firing. Structural design of the Crew Provisions Stowage Module would be less complex, and its weight would be reduced.

To provide carbon dioxide control for a 28 day decoupled mission, the LM-A will carry approximately 180 pounds of CM LiOH. This supplements the 10 day Apollo CM supply, and is not required if there is no decoupled mission capability.

Crew training and mission planning efforts would be decreased if the crew does not have to be prepared to perform both coupled and decoupled missions. However, most of the planning and training for the coupled mission is applicable to the decoupled mission, and the additional effort for both is minor in relation to the total effort.

MAJOR CONFIGURATION OPTIONS

Many of the configuration changes that become possible if decoupled mission capability is eliminated also eliminate the capability to manually dock the LM-A to the MDA. Manual docking capability, which exists in the Apollo LM, will be removed from LM-A in the present baseline configuration. To man the LM-A, the CM-SM must dock to it and thus establish the decoupled mission configuration. A sure decoupled mission would not then be sacrificed for a possible primary coupled mission which would require separation of the crew and two more docking operations. If there is no capability to perform a decoupled mission, it would be desirable to retain the Apollo manual docking capability as this would then be the only way to save the ATM in the event the LM-A fails to dock under remote control. In the following discussion of configuration options, it will be indicated if the change is possible if manual backup docking capability is retained.

Probe Location

The present baseline configuration locates the docking probe for LM-ATM/MDA docking in MDA port 1. It will be installed by the AAP-3 crew. A jettisonable docking port cover is provided so that the operation can be performed in a pressurized environment. If there is no decoupled mission or backup manual docking capability, the LM-A does not have to have a drogue because the CM-SM would never dock to it. If the probe is installed in the LM-A, the MDA would have the passive drogue which would be installed prior to launch, and a cover would not be necessary. However, provisions for remote probe operation would have to be added to the LM-A, and the MDA/CM command link electronics would be complicated. Results of a detailed trade-off would probably favor the probe in the LM-A configuration if the CM-SM does not have to dock to it.

Crew Provisions Stowage Module

Deletion of the CPSM from the LM-A can be considered if decoupled mission capability and manual docking capability are eliminated. It is possible to fit the items now located in the CPSM in the LM cabin. To mount these items, fairly extensive modifications to the LM primary structure would be required, and flexibility to accommodate additional items in the GFE complement would be extremely limited. Access to the LM-A cabin for required checkout during pad activities would be inhibited, and could lead to a requirement for cabin access via the top hatch. Most of the stowed items would have to be removed after docking to the MDA and placed elsewhere, and a second set of stowage provisions would be required. For ATM EVA, the crew would have to move the cameras and film back to the LM cabin. There are, in the present configuration, many ECS components located on the CPSM, and these would have to be relocated. The aft radiator area would have to be reduced below the requirement because of loss in module height. Bending loads induced at the LM-A/MDA interface by the docking of a revisit CM-SM cannot be carried without the CPSM. Based on these considerations, it appears that the CPSM should be retained, even if decoupled mission capability is eliminated.

EVA from LM-A

In a decoupled mission, EVA for ATM film exchange must be done from the LM, using the cabin as an airlock. This mode is also planned for the prime mission, as the distances to be traversed are shorter and egress/ingress problems are diminished. There are some savings in LM-A environmental control system hardware if EVA capability is eliminated and the Airlock Module is used for ATM EVA. The Liquid Cooled Garment Support Section* could be deleted. The Oxygen Supply and Cabin Pressure Control Section* could be deleted if it were not required to provide a pressure reference to the Water Management Section for water sublimator control during unmanned rendezvous and docking. However, this function could be provided by a simplified device.

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* For complete description of the functions and configurations of these LM-A ECS Sections, see "LM-A Thermal Control System," Bellcomm Memorandum for File, D. P. Woodard, September 27, 1968.

One of four water tanks could be deleted from the Water Management Section.* Most of these changes are not feasible if backup manual docking capability is retained.

There are, however, many disadvantages in doing ATM EVA from the Airlock Module rather than the LM-A. A film transport device is planned to eliminate the need for a substantial number of back-and-forth traverses. This device would have to be assembled in orbit if EVA is from the AM. Problems with a long umbilical (dynamics, snagging, stowage, and reeling-in) can easily occur. Zero-g training is more complex as the AM to ATM mode does not lend itself to neutral bouyancy or KC-135 tests as readily as the LM-A to ATM mode. Getting in and out of the AM is itself a problem; two suited astronauts plus a full film and camera complement crowd the AM.

EVA and film transport from the LM-A are less complex and will save both preparation and outside time. Safety is definitely enhanced. EVA from the LM-A should be retained as the primary mode in the primary coupled mission, independent of possible elimination of decoupled mission capability.

LM-A Dormancy

The question of increased LM-A dormancy has been examined by Grumman. Some essential LM-A equipment, such as the caution and warning electronics assembly and the lighting control assembly, as well as the ATM Control and Display console, must be kept on throughout the mission. Much of the essential equipment requires active cooling, and in the baseline configuration, a radiator network has been added which is linked through a heat exchanger to the primary Apollo LM coolant circuit. Most of the Grumman effort on the dormancy question was spent on investigation of ways to simplify or eliminate this radiator loop. If the heat rejection function is eliminated from the LM-A, it must be placed on the AM or CM-SM. The AM radiators do not have sufficient capacity to handle the AAP-2 integrated thermal control system load plus the LM-ATM load. The SM radiators could handle the additional load except during EVA from the LM. However, the addition of coolant interfaces between the LM-A and MDA, the MDA and CM-SM, plus required plumbing, pumps, valves, and heat exchangers in both the MDA and CM-SM practically dictate that the LM-A be thermally independent of other modules. The optimum level of LM-A system utilization is not a function of the type of mission (coupled or decoupled). In fact, decreasing the present baseline level of system utilization would be more complicated in the prime than in the decoupled mission, because the MDA would also have to be modified.

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* Ibid.

CMG Location

If there is no decoupled mission capability, the ATM CMG's could be located on the AAP-2 payload instead of the AAP-4 ATM. This change in configuration could eliminate the need for the bipropellant WACS if a cold gas attitude control system were added to maintain control during docking maneuvers. This change would also allow a 56 day AAP-3 mission with the OWS in the event the LM-ATM does not dock. The present WACS would not have sufficient propellant remaining to maintain the perpendicular-to-orbit plane attitude for another 56 day mission.

A cold gas/CMG attitude control system has been examined by MSFC. It was dropped from consideration because it weighed about 1500 pounds more and required about 550 watts more than the present WACS. In view of present weight and power margin on AAP-2, it appears impossible to meet these additional requirements. AAP-4, on the other hand, has a substantial performance margin and there is no advantage in removing the weight and power requirement of the CMG's. These factors, plus the state of development of both the ATM and the WACS, lead to the conclusion that the CMG's should be left on the ATM.

SUMMARY AND RECOMMENDATION

The obvious simplifications that are possible if all capability for a CM-SM/LM-ATM decoupled mission is deleted are minor. A change in the LM-MDA docking probe location is the only one of the major configuration changes that appears attractive if decoupled mission capability is eliminated, and this change is not possible if LM backup manual docking capability is retained.

Because the additions for decoupled mission capability are relatively minor and because of the state of design of the various modules (either approaching or past Preliminary Design Review), it is recommended that decoupled mission capability be retained in AAP, and that planning for both LM-ATM backup and alternate missions be continued.

William W. Hough

1022-WWH-ms W. W. Hough

Attachment
Appendix

APPENDIX

Failure Modes Which Preclude Primary ATM Mission, But Have Recovery Possibility With A CM-SM/LM-ATM Decoupled Mission

I. Decision to implement backup mission made prior to launch of AAP-3 and AAP-4.

   A. A known failure of OWS prior to launch of AAP-3, reported by previous crews or by remote status monitoring.

      1. WACS (CSM cannot dock to OWS)

      2. Power system

      3. MDA structure (cannot be pressurized)

   B. OWS schedule slip past point of CM-SM and LM-ATM availability.

II. Decision to implement alternate mission made after launch of AAP-3, but prior to AAP-4.

   A. CM-SM orbits, but doesn't rendezvous. LM-ATM launched into CM-SM orbit.

      1. Excessive CM-SM fuel consumption

      2. One CM-SM RCS system (600 lbs) fails

   B. CM-SM can't dock.

      1. OWS tumbling

      2. Port 5 drogue damaged

   C. OWS failure not known prior to CM-SM docking.

      1. MDA hatches cannot be removed

      2. OWS solar arrays damaged in CM-SM docking

      3. OWS solar arrays cannot be articulated from storage to AAP-3/AAP-4 position

      4. MDA environmental control system

5. MDA structure

6. MDA probe cannot be installed

7. MDA Port 1 cover does not jettison

D. CM-SM failure precluding clustered mission.

1. Loss of a full O_2 cryo tank prior to OWS pressurization, and assuming OWS is open to MDA and cannot be closed. (Decoupled mission requires 2 of 3 tanks)

2. Failure of redundant VHF command link for remote LM-ATM docking.

III. Decision to implement alternate mission made after launch of AAP-3 and AAP-4.

A. LM orbits but doesn't rendezvous.

1. Excessive LM-RCS consumption

2. RCS jets

3. PGNCS and AGS

(Ground commanded prime rendezvous mode backed up by onboard automatic mode; S-bank command link redundant)

B. LM doesn't dock.

1. MDA to CM-SM to LM-A VHF redundant command link

2. LM mission programmer

3. Control electronics section

4. AGS (LM not tumbling)

5. Aft firing LM-RCS thrusters

6. MDA probe doesn't retract (probe and drogue can be manually separated, but probe cannot be manually retracted)

C. OWS failure not known prior to LM-A docking.

1. Port 1 MDA hatch cannot be removed

2. OWS solar arrays damaged in LM-A docking

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